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DRAG AND STABILITY DATA FOR MODELS OF THE MK 76 MOD 4 PRACTICE BOMB OBTAINED FROM FREE-FLIGHT FIRINGS

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DRAG AND STABILITY DATA FOR MODELS OF THE MK 76 MOD 4 PRACTICE BOMB OBTAINED FROM FREE-FLIGHT FIRINGS

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ABSTRACT: A series of 0.45 scale models of the Mk 76 Mod 4 Practice Bomb were fired in the Naval Ordnance Laboratory Aerodynamics Range No. 1 within the Mach number range of 0.45 to 2.04 to obtain drag and stability coefficients.

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PRACTICE BOMB OBTAINED FROM FREE-FLIGHT FIRINGS

This report presents the results of firings made with models of the Mk 76 Mod 4 Practice Bomb in the Naval Ordnance Laboratory Aerodynamics Range No. 1 to determine their free-flight characteristics.

This work was done at the request of the Naval Weapons Laboratory, Dahlgren, Virginia, under task number NOL-526.

W. D. COLEMAN
Captain, USN
Commander

A. E. SEIGEL
By direction

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SYMBOLS

$C_D = \frac{D_t}{qS}$ = total drag coefficient based on the maximum body cross-sectional area(S) of the model

C_{M_α} = (slope of the pitching moment)/qSD = slope of the pitching moment coefficient referred to the CG

$C_{M_q} + C_{M_{\dot\alpha}}$ = (slope of yaw damping moment due to q)/$(\frac{D}{2V})$ qSD + (slope of yaw damping moment due to $\dot\alpha$)/$(\frac{D}{2V})$ qSD = slope of damping moment coefficient referred to the CG

C_{N_α} = (slope of normal force)/qS = slope of normal force coefficient

CG = center of gravity

CP = center of pressure

D = maximum body diameter of model

D_t = component of the aerodynamic force directed along the trajectory

I = moment of inertia about CG, I_A denotes axial and I_B, transverse

k_D, k_M = parameters used to correct to zero yaw the drag and pitching moment coefficients, respectively

M = Mach number (based on midrange value of V)

P.E. = probable error based on accuracy of data fitting (P.E.s, swerve equation; P.E.y, yaw equation)

$q = \frac{\rho V^2}{2}$ = dynamic pressure; or q = lateral component of angular velocity of model

$Re_L = \frac{\rho VL}{\mu}$ = Reynolds number based on maximum length (L) of model

$S = \frac{\pi D^2}{4}$ = maximum cross-sectional area of body of model

V = velocity (usually a midrange value)

SYMBOLS

α = angle of attack

$\dot{\alpha}$ = rate of change of angle of attack with time

δ^2 = mean squared yaw

μ = coefficient of viscosity

ρ = density of air

λ_1, λ_2 = damping rates of nutational arm (1) and precessional arm (2)

Subscript

o coefficient corrected to zero yaw

INTRODUCTION

1. Models of the Mk 76 Mod 4 Practice Bomb were fired in the Naval Ordnance Laboratory Aerodynamics Range No. 1 (reference (a)) to determine their drag and stability characteristics within the Mach number range of 0.45 to 2.04.

MODEL DETAILS

2. Figure 1 is a sketch of the model of the Mk 76 Mod 4 Practice Bomb. Table I lists the average physical dimensions of the models. Figure 2 shows the model with an exploded view of its sabot. Figure 3 shows the model and sabot in a package ready for loading in the gun. The models were 0.45 the size of their prototypes. Figures 4 and 5 are shadowgraph prints of the model in flight at Mach numbers of 0.556 and 2.082, respectively.

DISCUSSION AND RESULTS

3. The drag and stability coefficients for the models of the Mk 76 Mod 4 Practice Bomb were obtained using data reduction techniques described in reference (b).

4. Table II lists the drag coefficients, both uncorrected and corrected to zero yaw, for the models of the Mk 76 Mod 4 Practice Bomb. Because of the high drag of the configuration and the large number of stations (33) in the 330-ft. NOL Aerodynamics Range No. 1, drag data at several Mach numbers were obtained from each round. Figure 6 is the drag curve corrected to zero yaw for the models of the Mk 76 Mod 4 Practice Bomb. These coefficients were corrected to zero yaw by using the equation

$$C_{D_o} = C_D - k_D \quad \delta^2.$$

Values for k_D were obtained by grouping the data within specific Mach number regions.

5. Table III contains the stability data obtained from firing models of the Mk 76 Mod 4 Practice Bomb. The slope of the pitching moment coefficient was corrected to zero yaw by using the equation

$$C_{M_{\alpha_o}} = C_{M_\alpha} - k_M \quad \delta^2$$

where again the factor k_M was determined from a number of rounds within a specific Mach number region. Figure 7 is a plot of the slope of the pitching moment coefficient corrected to zero yaw as a function of Mach number.

6. The slope of the normal force coefficient and the slope of the damping moment coefficient were not corrected to zero yaw because of their high probable errors and the resultant scatter in the coefficients. However, the uncorrected coefficients were plotted. Figure 8 is a plot of the slope of the normal force coefficient, and Figure 9 is a plot of the slope of the damping moment coefficient.

CONCLUSIONS

7. Drag and stability coefficients were obtained for 0.45 scale models of the Mk 76 Mod 4 Practice Bomb within the Mach number range of 0.45 to 2.04. The data are presented in tabular and graphic form.

REFERENCES

(a) May, A. and Williams, T. J., "Free-Flight Ranges at the Naval Ordnance Laboratory," NavOrd Report 4063 (1955)
(b) Murphy, C. H., "Data Reduction for the Free-Flight Spark Ranges," BRL Report No. 900 (1954)

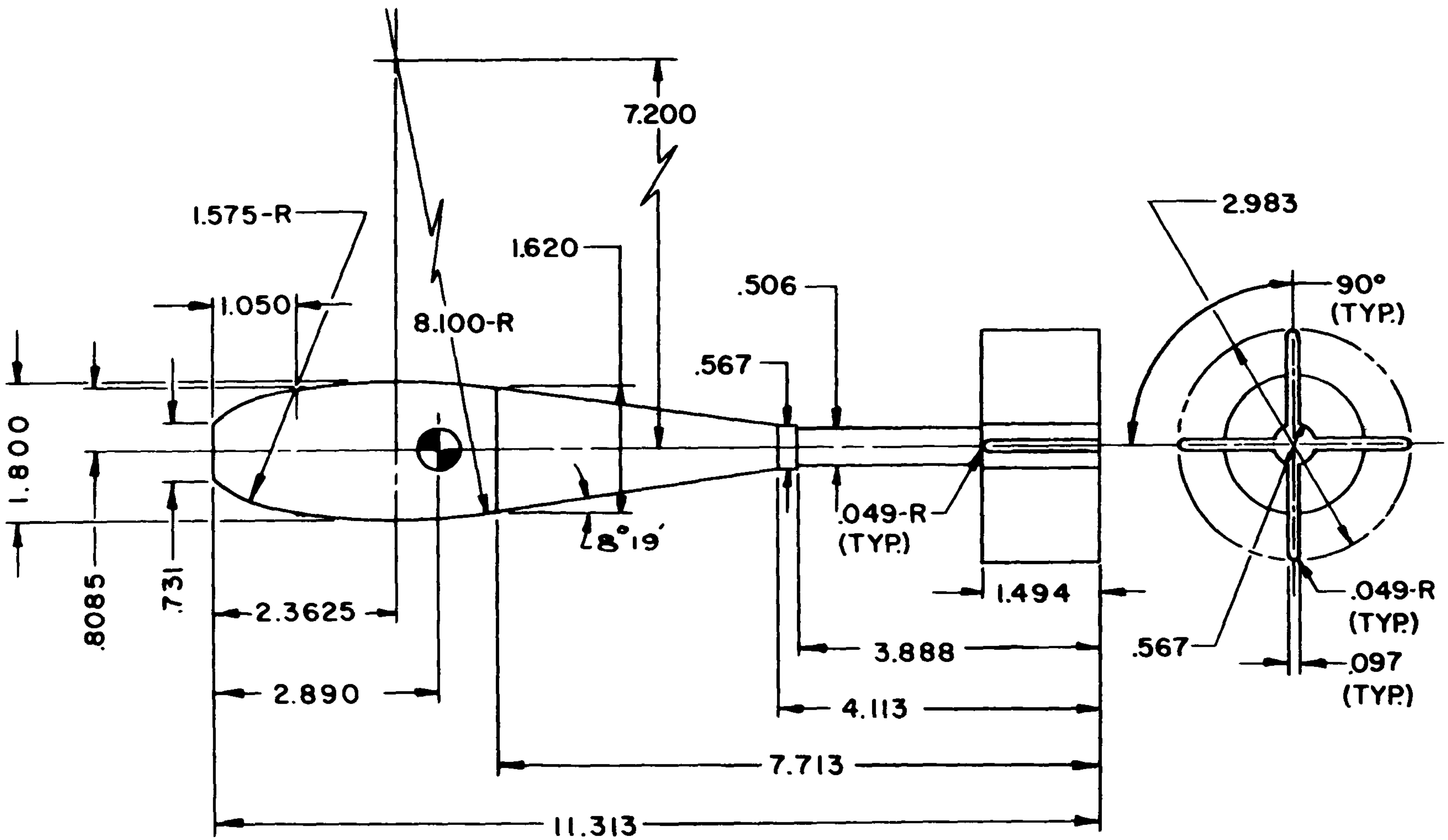

FIG. I MODEL OF MK 76 MOD 4 PRACTICE BOMB

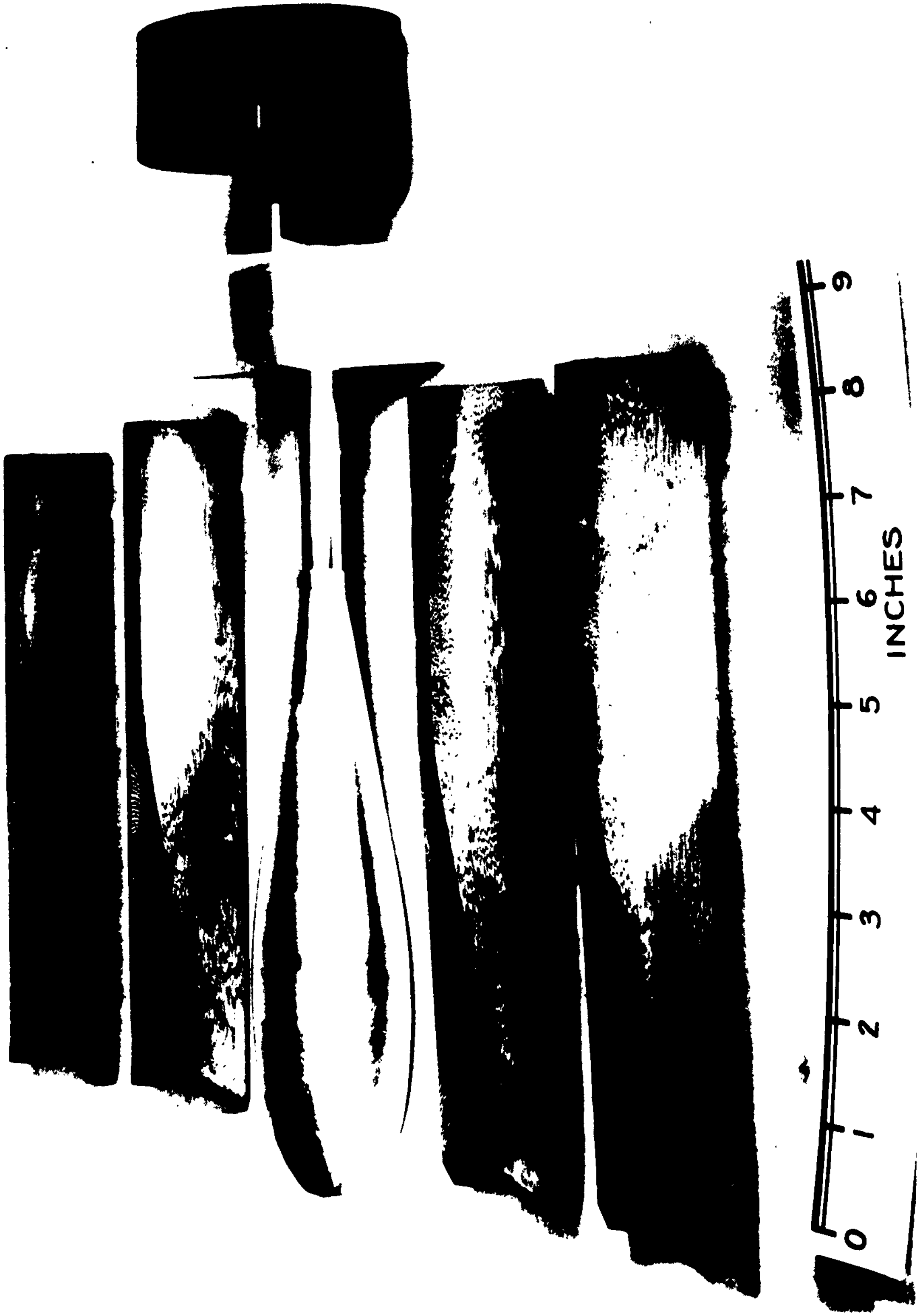

FIG. 2 MODEL OF MK 76 MOD 4 PRACTICE BOMB WITH ITS EXPLODED SABOT

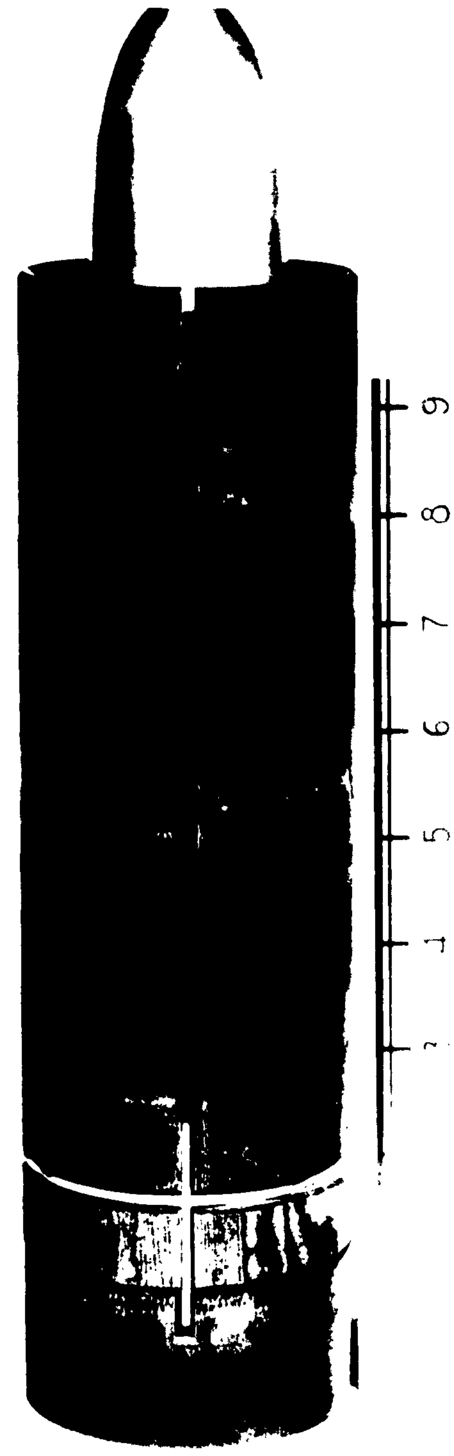

FIG. 3 MK 76 MOD 4 PRACTICE BOMB MODEL AND SABOT PACKAGE

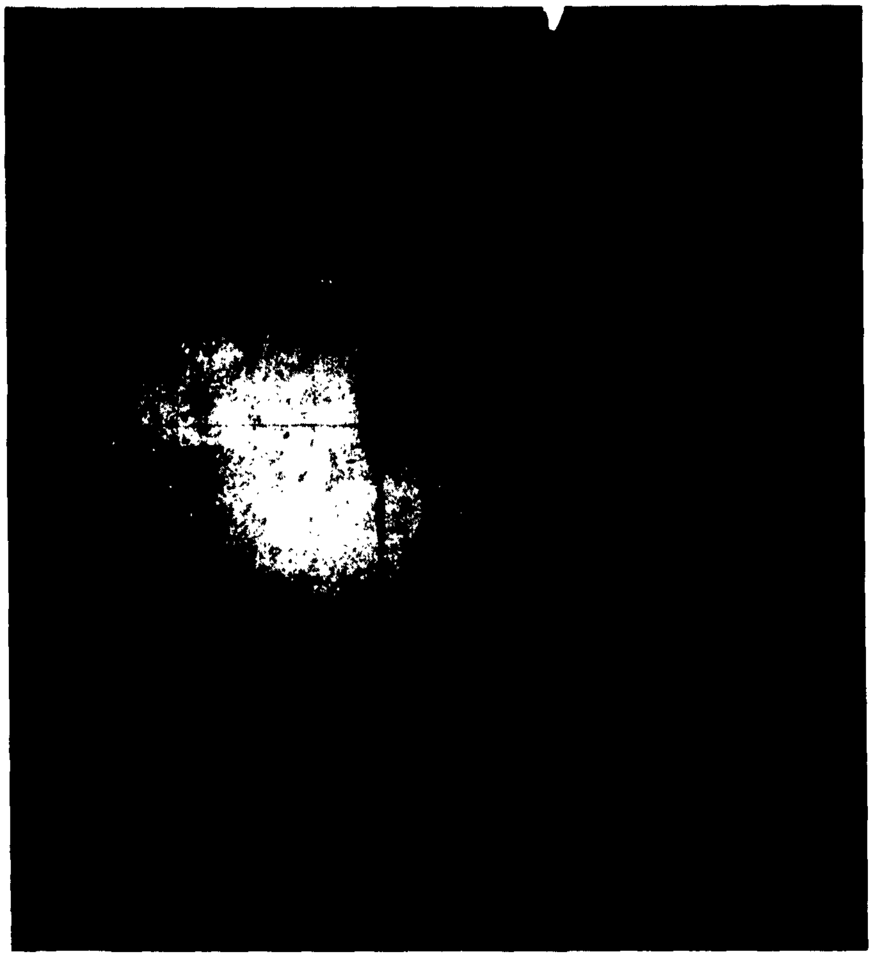

FIG. 4 SHADOWGRAPH PRINT OF MODEL OF MK 76 MOD 4 PRACTICE BOMB, RD. 1521, M=0.556

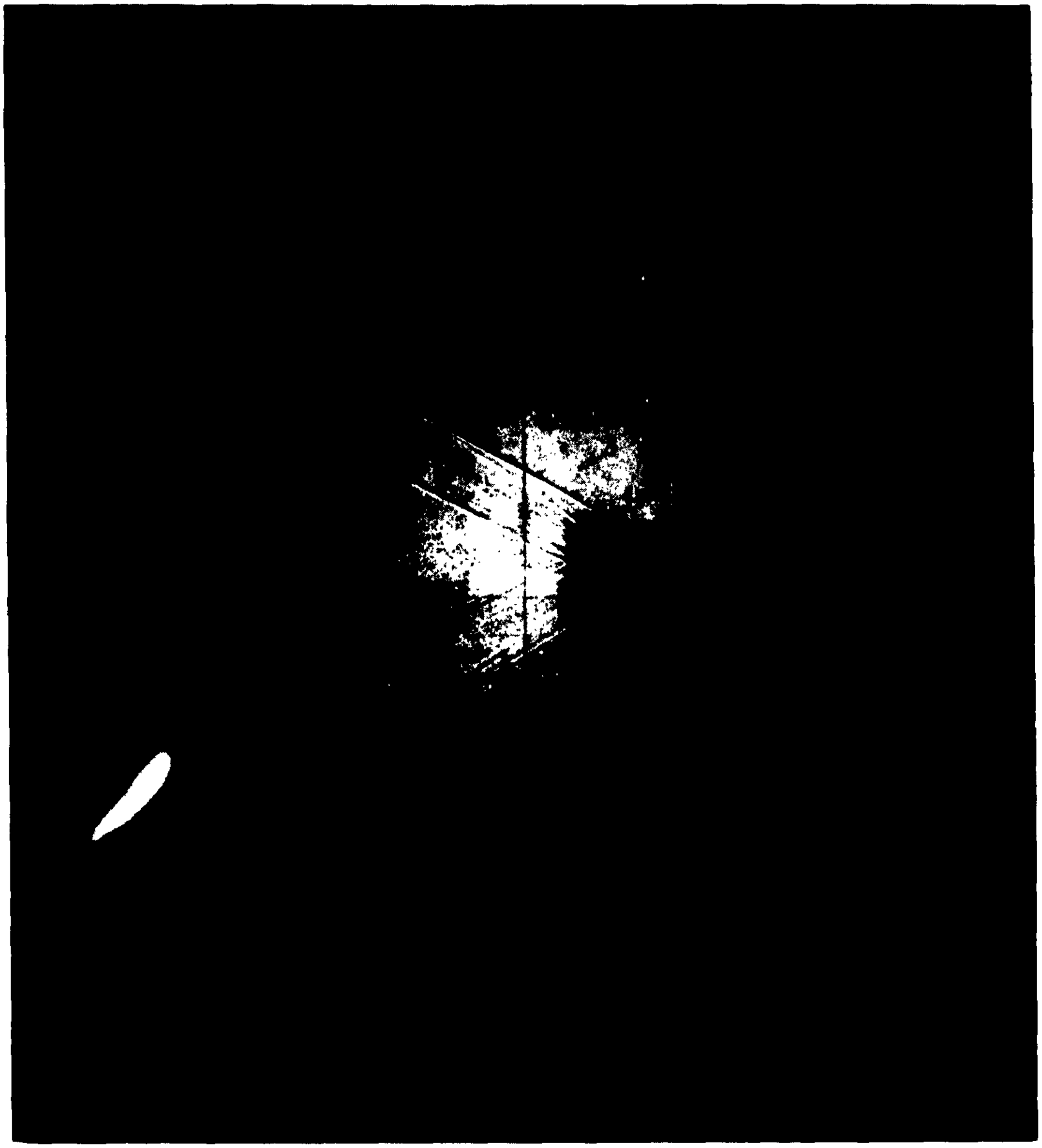

FIG. 5 SHADOWGRAPH PRINT OF MODEL OF MK 76 MOD 4 PRACTICE BOMB, RD. 1510, M = 2.082

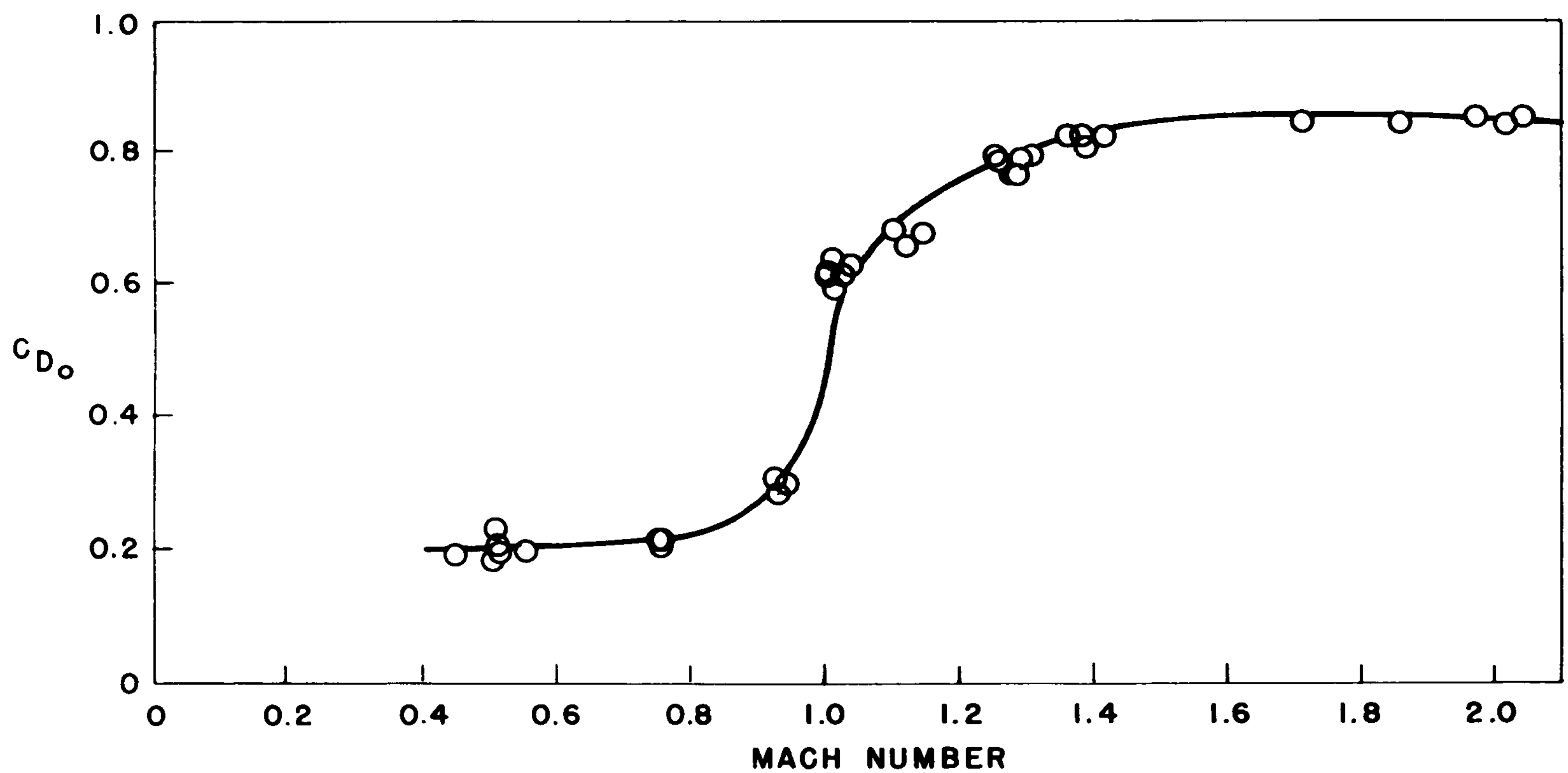

FIG. 6 ZERO YAW DRAG COEFFICIENT FOR MK 76 MOD 4 PRACTICE BOMB MODELS AS A FUNCTION OF MACH NUMBER

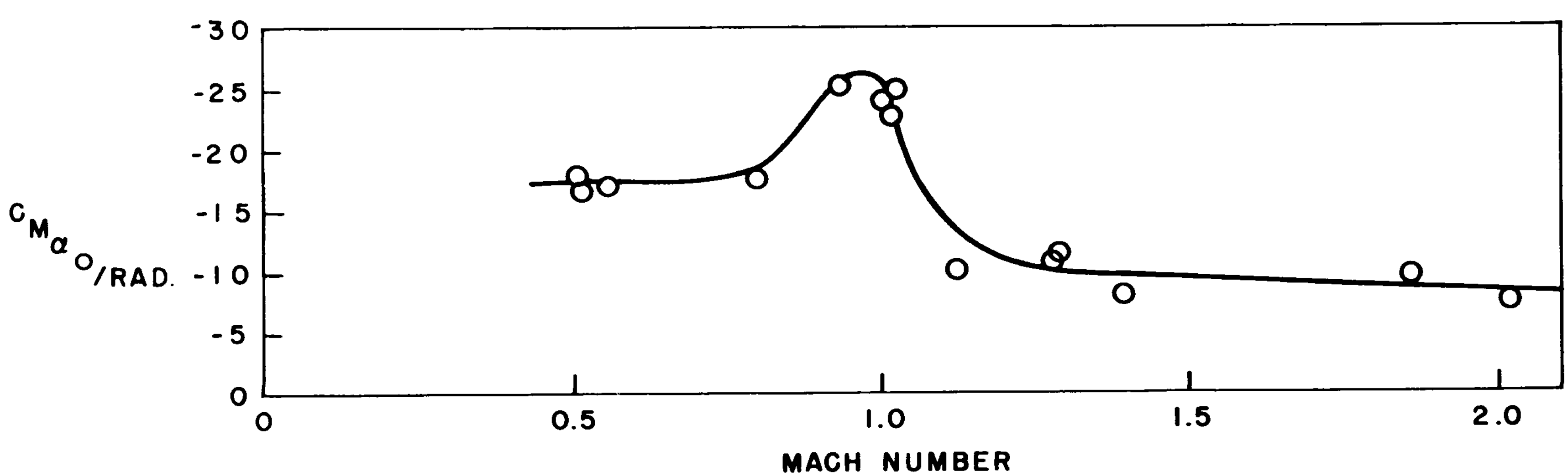

FIG. 7 SLOPE OF THE PITCHING MOMENT COEFFICIENT CORRECTED TO ZERO YAW AS A FUNCTION OF MACH NUMBER

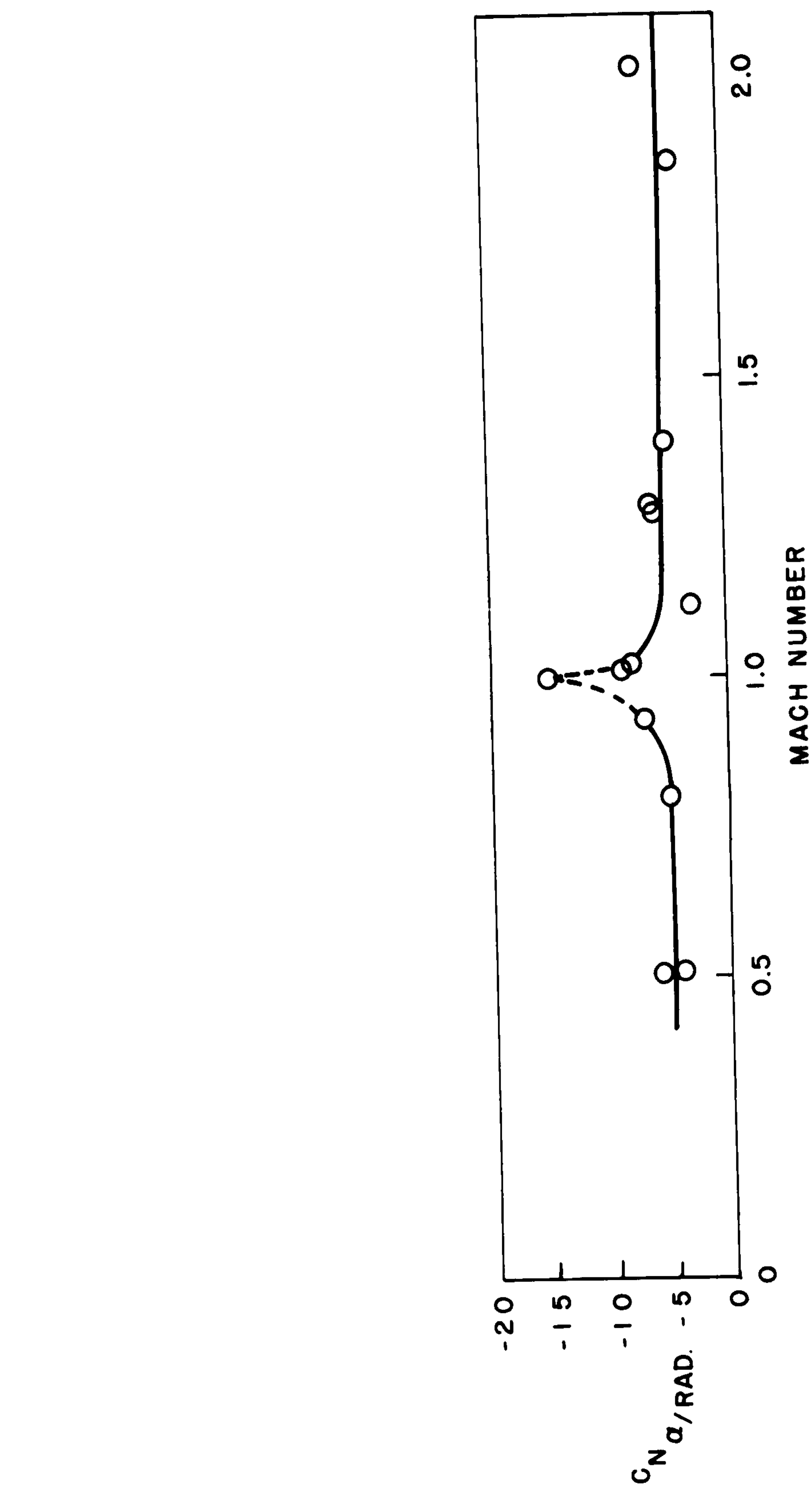

FIG. 8 SLOPE OF THE NORMAL FORCE COEFFICIENT AS A FUNCTION OF MACH NUMBER

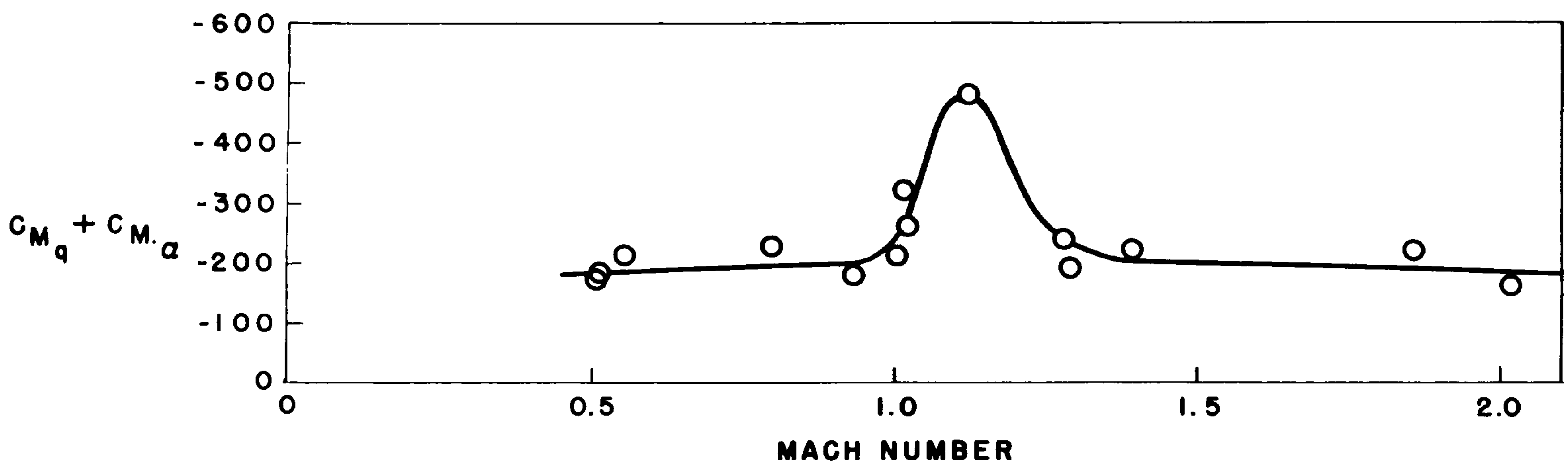

FIG. 9 SLOPE OF THE DAMPING MOMENT COEFFICIENT AS A FUNCTION OF MACH NUMBER

TABLE I

AVERAGE PHYSICAL DIMENSIONS OF MODELS OF MK 76 MOD 4 PRACTICE BOMB

Max. Body Dia. (In.)	Length (In.)	Weight (Grams)	CG (In. from nose)	I_B (Gram-In.^{2})	I_A (Gram-In.^{2})
1.800	11.313	1137.33	2.890	5963.2	292.9

TABLE II

DRAG DATA FOR MK 76 MOD 4 PRACTICE BOMB

Round No.	M	C_D	P.E. ($\pm$)	$Re_L \times 10^{-6}$	δ^2 (Deg.^{2})	C_{D_o}
1510	2.042	.926	.002	13.15	39.4	.852
1510	2.018	.888	.001	13.00	25.2	.841
1510	1.973	.864	.004	12.71	4.2	.856
1509	1.858	.851	.001	11.96	3.9	.844
1508	1.712	.856	.001	10.96	4.6	.847
1511	1.416	.987	.003	9.119	87.5	.827
1511	1.392	.902	.001	8.966	50.9	.809
1512	1.380	.825	.001	8.810	1.2	.823
1511	1.364	.834	.003	8.784	6.2	.823
1513	1.306	.921	.002	8.344	48.6	.792
1507	1.295	.886	.002	8.228	35.8	.791
1513	1.286	.840	.001	8.216	27.9	.766
1507	1.273	.816	.001	8.087	20.8	.761
1513	1.260	.795	.005	8.046	4.1	.784
1507	1.252	.800	.003	7.958	1.6	.796
1514	1.146	.838	.007	7.332	34.5	.679
1514	1.121	.747	.002	7.172	19.8	.656
1514	1.100	.683	.010	7.039	1.2	.677
1517	1.036	.765	.007	6.624	49.6	.623
1518	1.026	.690	.002	6.614	27.1	.612
1517	1.023	.688	.002	6.539	29.5	.604
1518	1.014	.638	.001	6.536	16.1	.592
1517	1.009	.639	.009	6.450	2.0	.633
1572	1.002	.621	.010	6.373	2.7	.613
1518	1.001	.612	.003	6.451	1.1	.609
1515	0.944	.354	.002	5.999	12.1	.295
1573	0.937	.333	.002	5.921	6.2	.303
1573	0.932	.298	.001	5.887	3.6	.280
1573	0.926	.306	.004	5.855	0.8	.302
1520	0.757	.283	.006	4.838	42.9	.214
1520	0.754	.244	.002	4.816	26.9	.200
1520	0.749	.216	.004	4.786	1.5	.214
1521	0.555	.207	.001	3.546	7.2	.195
1575	0.513	.243	.002	3.256	27.7	.198
1575	0.511	.221	.001	3.245	11.7	.202
1575	0.509	.235	.005	3.228	2.3	.231
1522	0.507	.203	.001	3.219	13.5	.181
1574	0.450	.191	.004	2.870	2.6	.187

TABLE III

STABILITY DATA FOR

MK 76 MOD 4 PRACTICE BOMB

ROUND NO.	M	$Re_L \times 10^{-6}$	δ^2 (Deg.^{2})	P.E.γ (Rad.)	P.E.Δ (In.)	C_{M_α}/Rad.	P.E. (±)	$C_{M_{\alpha_0}}$/Rad.	C_{N_α}/Rad.	P.E. (±)	$C_{M_q} + C_{M_{\dot\alpha}}$	P.E. (±)	C.P. - C.G. (Cal.)	$\lambda_1 \times 10^3$ (1/Ft.)	$\lambda_2 \times 10^3$ (1/Ft.)
A-1510	2.018	13.00	25.4	.01	.08	-9.44	.08	-7.49	-7.1	0.7	-160	10	1.33	-7.226	-7.139
A-1509	1.858	11.96	3.0	.01	.1	-9.7	.3	-9.5	-4	6	-220	40	2.52	-9.281	-9.409
A-1511	1.392	8.966	51.6	.02	.1	-12.0	.2	-8.0	-4.9	0.9	-220	30	2.47	-10.66	-7.730
A-1513	1.286	8.216	23.2	.01	.05	-13.1	.1	-11.3	-6.4	0.9	-190	10	2.03	-7.846	-8.545
A-1507	1.273	8.087	18.8	.009	.08	-11.9	.1	-10.5	-6	1	-240	20	1.92	-7.179	-13.14
A-1514	1.121	7.172	18.4	.02	.08	-11.4	.7	-10.0	-3	2	-480	70	3.26	-29.16	-9.920
A-1517	1.023	6.539	26.8	.01	.08	-19.6	.3	-24.8	-8	2	-260	30	2.48	-12.47	-10.37
A-1518	1.014	6.540	14.3	.02	.08	-20.0	.5	-22.7	-9	3	-320	50	2.22	-17.92	-10.67
A-1572	1.002	6.373	2.7	.006	.08	-23.3	.4	-23.8	-15	5	-210	30	1.56	-7.160	-13.691
A-1573	0.932	5.987	3.6	.004	.05	-24.5	.2	-25.2	-7	2	-180	20	3.29	-7.842	-8.211
A-1519	0.798	5.136	3.7	.007	.08	-16.6	.3	-17.5	-5	4	-230	30	3.36	-12.32	-7.893
A-1521	0.555	3.545	10.4	.01	.1	-14.6	.3	-17.0	--	--	-210	50	—	-7.031	-9.413
A-1575	0.511	3.245	11.8	.007	.08	-13.9	.1	-16.6	-4	2	-180	10	3.29	-7.443	-8.241
A-1522	0.507	3.219	14.1	.009	.1	-14.6	.2	-17.9	-6	5	-170	30	2.33	-8.340	-6.576

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A series of 0.45 scale models of the Mk 76 mod 4 practice bomb were fired in the Naval Ordnance Laboratory aerodynamics range no. 1 within the Mach number range of 0.45 to 2.04 to obtain drag and stability coefficients.

1. Bombs, Practice - Mark 76 mod 4
2. Bombs, Practice - Drag
3. Bombs, Practice - Stability
4. Bombs, Practice - Wind tunnel tests

I. Title
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III. Series
IV. Project

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